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TREATMENT EFFECTIVENESS EVALUATION OF WASTEWATER FROM INDUSTRIAL FRIED CHICKEN RE- PROCESSING PROCESSES BY ADVANCED OXIDATION PROCESSES

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ABSTRACT

The experiment was conducted by using ozone and graphite electrodes to treat wastewater from industrial fried chicken re-processing peocesses with COD value ranges of 1600 - 2000 mgO_2/L. A chamber of 20 liters was used in this study. The chamber height was 1 meter (the high response of 50-60 cm) in order to increase the diffusion of ozone into the wastewater. The study results showed that the amount of ozone needed for the reaction is 300 mg/h with COD removal efficiency of 40 % during reaction time of 45-60 minutes.The rate of BOD/COD increased within 1.55 - 1.80 times as compared with the BOD/COD rate of the initial wastewater. The experiments also showed that the COD removal efficiency of wastewater was not affected much by the pH value of the wastewater.

Keywords: re-processing wastewater, industrial fried chicken, BOD, COD, graphite electrode.

1. INTRODUCTION

To treat wastewater from industrial fried chicken pre-processing processes by direct application of biological methods is not feasible due to the inhibition of biological compounds in spices. To treat this wastewater effectively by biological method, it is necessary to use a pre-treatment method in order to reduce or eliminate effect of spices in wastewater. A method to eliminate biological inhibition compounds is advanced oxidation procesess. Some studies reported the oxidation methods combined with biological methods (plant, activated sludge, etc.) for wastewater treatment. Olive mill wastewater is the kind of wastewater with a very high organic concentration, persistent in nature and contains many toxic compounds with microorganisms. The application of advanced oxidation processes as a pre-treatment step for

wastewater treatment of olive oil production has significantly reduced the concentration of organic substances. Then, the wastewater applied is easy to be treated by biological processes [1]. A study of the wastewater treatment plant of pharmaceutical manufacturers with the advanced oxidation method combining biological methods reported that the COD removal efficiency is 8-30 %, the ratio of BOD_5/COD increases from ranges of 0.26-0.35 to ranges of 0.64-0.69 (up from 2.0 to 2.5 times) for photochemical generation of UV/H_2O_2 at pH of 8.0; the COD removal efficiency is 43-50 %, the ratio BOD_5/COD increases from ranges of 0.15-0.17 to ranges of 0.41-0.43 for the photochemical generation of UV / H_2O_2 / Fe^{2+} at pH of 2.5. Then, this wastewater is well treated by activated sludge method [2]. Another study reported the enhanced biodegradation of wastewater after pretreatment with the process AOPs (UV/O_3, UV/H_2O_2, fenton). The values of BOD_5, COD, and the ratio BOD_5/COD change positively. Thus, the combination of the advanced oxidation and biological processes has the feasibility in the technical method, economic costs and environmental implications [3]. This study was investigated using the advanced oxidation process combined between ozone and electrolysis of graphite electrolydes to treat wastewater from industrial fried chicken re-processing process.

2. MATERIAL AND METHODS

2.1. Subjects

Table 1. Synthetic components manufacturing industry wastewater from marinated chicken - fast food.

No	Parameter	Unit	Company			Test method
			McDonald's	**KFC**	**Jollibee**	
1	pH	-	6.5-8.5	5,89	5,3-6,8	pH meter
2	COD	mgO_2/l	-	1.152	2800-5350	SMEWW 5220 C : 2012
3	BOD_5	mgO_2/l	150 - 250	920	1800-2140	TCVN 6001-1: 2008
4	Total Nitrogen	mg/l	20 – 80	30	147-370	TCVN 6628 : 2000
5	Total Phospho	mg/l	6 - 8	5,14	46-90	SMEWW 4500-P&D : 2012
6	Animal fat and vegetable oil	mg/l	-	351	7,8	EPA 1664 A : 2012

***Source*:** *Compiled from multiple sources.*

Processing chicken becoming semi-finished products: whole chicken is cut into small pieces which were washed 1st time to remove contamination on meat; washed 2nd time to clean bacteria, impurities scattered from the 1st time washing process; checked ingredients parasites; marinated - blended with spices (onion, garlic, chilli, ginger, milk, salt, seasoning, ...); packed by PE bag and stored frozen storage; finally, go to the place of processing and consumption. Wastewater from the marinated chicken semi-finished products: After each batch of chicken marinated in spices, mixing equipment should be cleaned, disinfected and prepared for the next batch mixing. This is the stage of the wastewater generated at the emitter: 7 m^3/tons of product. Wastewater was sampled directly from the sewage disposal system of this workshop. Table 1 shows organic concentrations in the wastewater from some manufacturers relating to industrial

fried chicken products. It is clear that the concentrations of BOD, COD, TN, and TP are very high which is needed to treat before discharge to surround environment. This study investigated wastewater of Jollibee company.

2.2. Methods

Experimental schematic was showed as in Figure 1. The chamber was a cylinder with diameter of 90 mm and height of 1000 mm. Ozone generation machine of capacity 3g/h was used to produce ozone during experimental periods. Flow rate of ozone was controled by flowmeter to calculate ozone concentration reacted with organic concentration. An electrolysis process using graphite electrolydes with 12V voltage to produce OH^- which combines with ozone to produce *OH as an advanced oxidation process. Test design was showed as in Figure 2. pH of wastewater was adjusted by using NaOH to test pH effect on treatment effectiveness.

Each batch of experiments was 20L waste water. Wastewater was prepared (adjusted pH to the desired value) and pumped into reactor switch. Ozone was adjusted flow rate to control the input ozone concentration as the desired values. The detailed experiments are presented as Table 2. Ozone residue was absorpted by the solution of KI. After each of the tests, the experimantel system was rinsed with clean water, drained and started the next experiment.

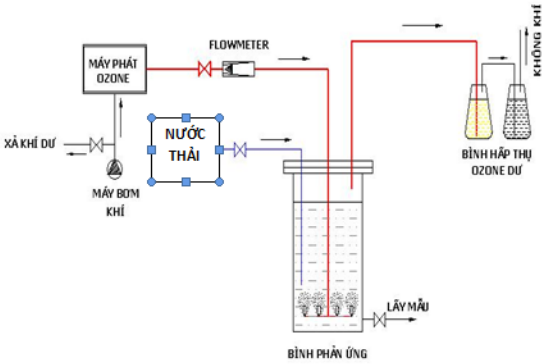

Figure 1. Principle of operation of experimental.

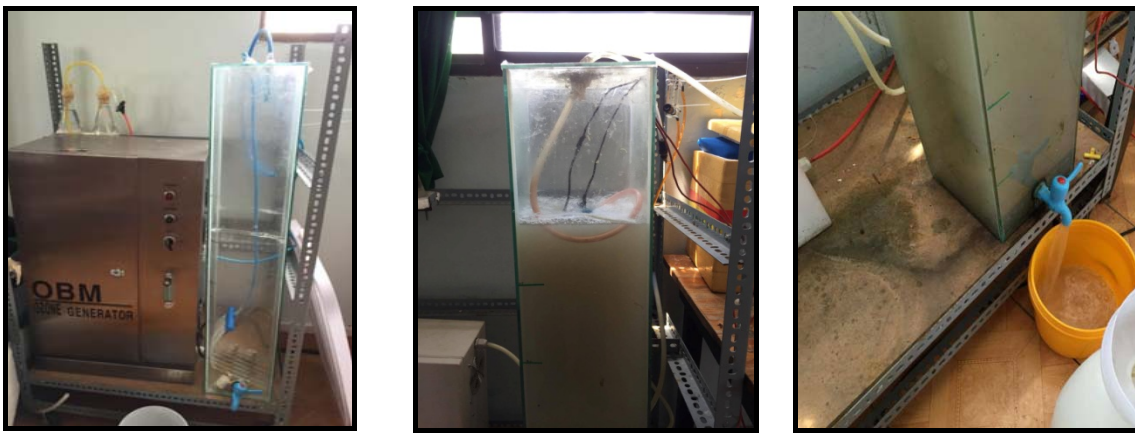

Figure 2. Actual experimental model.

Table 2. Experiments performed.

Experiment	Experimental operating parameters			
	Wastewater volume (l)	**pH**	**Ozone Concentration (mgO_3/h)**	**Time (min)**
Symbol: TN1 To study the effect of pH. + Indicator: pH, COD, BOD. + Laboratory Repeatability: 3 times	20	Experiment with 3 different pH values (7, 8 and 9)	200mg/h	0 – 60
Symbol: TN2 Studies of the effects of Ozone treatment efficiency + Indicator: pH, COD, BOD. + Laboratory Repeatability: 3 times	20	pH found in experiments TN1	Conducting experiments with 6 different values Ozone (Combined use of carbon electrodes - 12V)	0 – 120
Symbol: TN3 Control + Indicator: pH, COD, BOD. + Laboratory Repeatability: 3 times	20	+ The experiment used electrodes only, + Laboratory use only ozone (300mg/h) + Experiment using carbon electrodes (12V) and aeration Ozone (concentration of 300 mg/h).		0 – 90

3. RESULTS AND DISCUSSION

3.1. Effect of pH on the efficiency of wastewater treatment

In this experiment, we selected pH, COD and BOD_5 for research and performing the variation of ratio BOD_5/COD; the COD removal efficiency as showed in Figure 3a and b. From that, judgments about the reduction of the substances in wastewater were made by using the oxidation process. COD_{tb} removal efficiency in the experimental pH values tends to increase by time, but the variation is not high. With the response time to 60 minutes at 200 mg O_3/h, COD_{tb} removal efficiency still remained at low 10 %. After the 30-minute response time, reducing COD_{tb} values began to show signs of stability (in the response time of 30 minutes, 45 minutes and 60 minutes respectively ranged between 3-5 %, 4-7 % and 6-9 %), which suggests that ozone agent began attacking the substances in wastewater.

The ratio BOD_5/COD of wastewater after oxidation through at many different pH conditions increased as compared with the ratio BOD_5/COD of wastewater before process. In experiments to adjust the pH = 9, ratio BOD_5/COD had a strong variability, after a 15-minute response time, this percentage rose above 0.46 and 0.49 in the value of the response time of 60 minute. At experiment pH = 7 and pH = 8, the ratio BOD_5/COD after 15 minutes response time tends to increase. However, after the 60-minute response time, the ratio of BOD_5/COD tends to stabilize at ranging from 0.47 to 0.49.

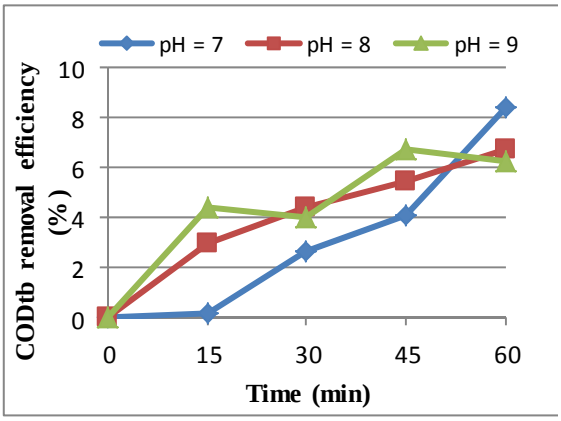

Figure 3a. COD_{tb} removal efficiency.

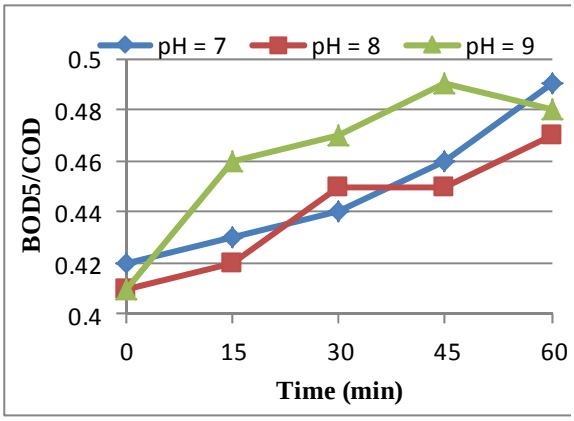

Figure 3b. The ratio BOD_5/COD.

The experiments studying the effect of pH on treatment efficiency of organic matter in the wastewater from industrial fried chicken pre-processing process showed that COD_{tb} handling efficiency in all 3 pH conditions are not high, ranged from 5 % to 9 %. COD concentration of wastewater has decreased during the reaction but not significantly decreased over time in all pH values with used ozone concentration of 200 mg/h. Removal efficiency of organic matter in the wastewater from the experiment was not significant at different pH values. The trend of the wastewater treatment process began with the transformation after 30-minute response time. From these results, pH of 7 was chosen to conduct next experiments in order to ensure the pH suitable condition for subsequent biology treatment and chemicals saving.

The COD removal efficiency was not high as using ozone agents as presented in Figure 3a. To improve the removal efficiency of organic substances in wastewater, the advanced oxidation process combined with ozone and electrolysis of graphite electrodes was applied for wastewater treatment. The advantages of ozone-electrolyte are no need to use other agents (hydrogen peroxide or iron salts), no creation of the chromaticity, and easy use [4].

3.2. Effect of ozone concentrations to wastewater treatment efficiency

The mechanism of the process O_3 is based on the ability oxidation to oxidize its organic compounds, or turn the organic matter decomposes from difficult to convenient. Ozonated process itself didn't appear OH* but OH* appeared to have the participation of the electrodes. Thus the use of electrodes combined with O_3 is a process of creating OH* radicals (oxidizing agent stronger to handle the organic matter). [4] [5].

In the response time from 0 to 60 minutes and ozone concentration of 150-400 mg/h combined with 12V graphite electrolydes at pH = 7(each is 50 mg/h increments), COD removal efficiency significantly increased over time and after 45 minutes reaction COD removal efficiency with large range (from 10-35 %) between concentration value ozone testing and when the reaction time was 60 minutes, the range continued to increase (15-40 %) as presented in Figure 4. In reaction time from 60 to 120 minutes, COD removal efficiency tends to decrease (approximately ranging from 10-35 %). This can be explained in the beginning of the response time (0-60 minutes), oxidation occurs powerful, simple substrates almost oxidized to COD removal efficiency increases, however, when simple compound was oxidation most, complex

compounds started being attacked by OH* radicals and splitted (this time COD removal efficiency decreased).

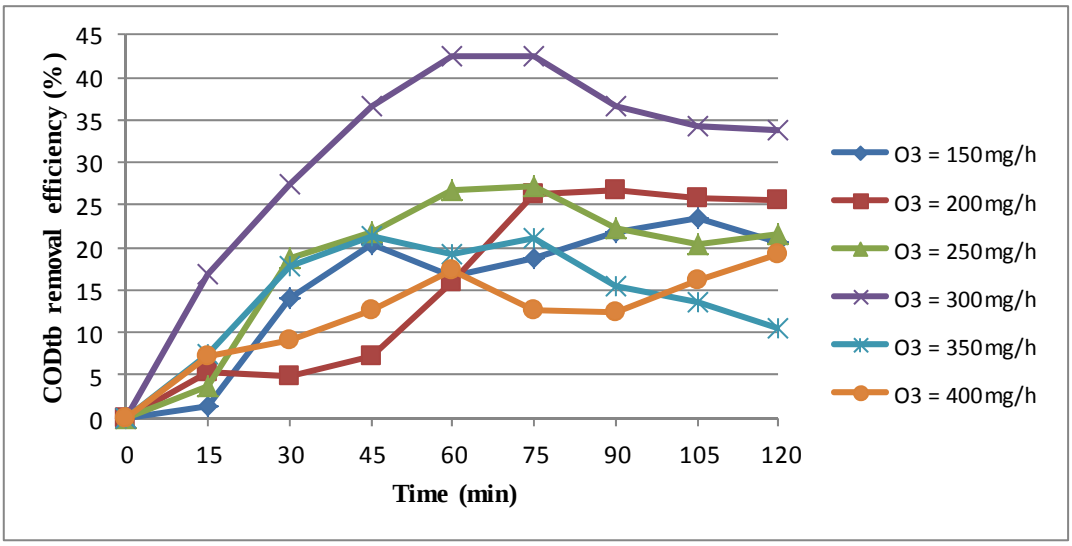

Figure 4. COD_{tb} removal efficiency.

In the range of ozone concentrations of of 150 - 200 mg/h 350 - 400 mg/h, COD removal efficiency of the whole process ranged within 5 - 27 %. Thus, ozone dose < 250 mg/h or > 300 mg/h are not effective for treatment as expected, could explain the low ozone doses < 250 mg/h is insufficient to process oxidising agent classified *OH radicals in wastewater, whereas the increase of ozone dose > 300 mg/h, it occurs the oxidant balance, *OH radicals react with each other self-wasters that COD removal efficiency is not high. The highest COD removal efficiency was over 40 % for ozone concentrations of 300 mg/h about 60-minute response time.

3.3 Experiment control

Comparison of the results of three experiments were conducted: The experiment used electrodes only; The experiment used only ozone (ozone concentration: 300mg/h); The experiment uses coal electrode voltages to 12V and aeration with Ozone concentration = 300mg/h. The volume batch experiments: 20L; Adjust the pH of the wastewater using solution NaOH 1N in value 7; Response time: 0 to 90 minutes (every 15 minutes takes sample one times). With the experiment use only oxidizing agent is ozone: COD removal efficiency increased slightly over time response, but the response to 90 minutes COD removal efficiency was less than 8 %; BOD removal efficiency with increased variability, but not significantly, after 90 minutes reaction BOD removal efficiency reached 17 %; Ratio BOD/COD ranged from 0.4 to 0.47, with no breakthrough. The preliminary treatment of waste water industrial fried chicken, ozone dose 300mg/h does not reduce the complex compound, this dosage can only easily oxidized compounds biodegradation substances into CO_2 and H_2O simple.

With the experiments use electrodes only: Efficiency of COD removal is low, after 90 minutes reaction vibration amplitude response of COD removal efficiency < 4 %; BOD removal efficiency appear negative values after 30 minutes of the experiment, however the negative performance not significantly is the highest - 4.8 %; Ratio BOD/COD ranged from 0.36 to 0.38,

most of them unchanged. We explain that under the effect of electrochemical energy, the compounds not biodegradable were irritated division.

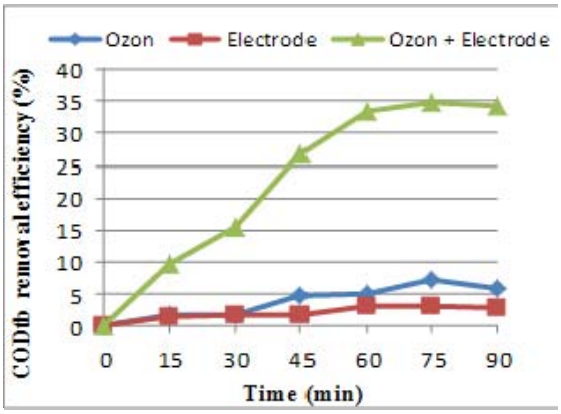

Figure 5. CODtb removal efficiency.

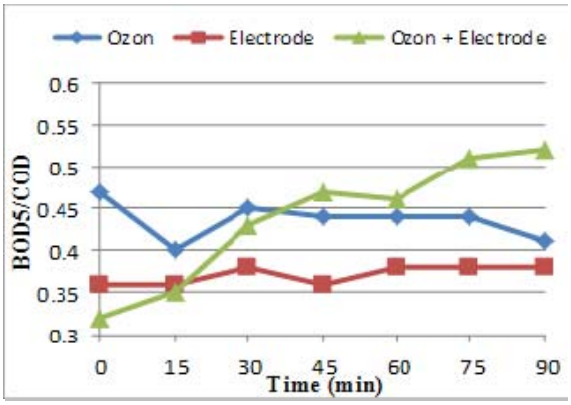

Figure 6. The ratio BOD_5/COD.

With experiments use coal electrodes combined Ozone: effeiciency remove COD, BOD increased with reaction time, COD removal efficiency after 30 minutes reached 15 % and after 60 minutes reached 34 %; Ratio BOD/COD increased from 0.32 before reaction to 0.52 (up to 1.63 times). Thus the harder biodegradation compound was transformed into simpler compounds.

4. CONCLUSION

The study showed that the COD removal efficiency of ozone agents is not high at any pH value for the oxidation with ozone. Therefore it was required supporting factors to improve processing performance. This research selected the electrolysis process as the support for the process to minimize the use of chemicals to avoid affecting the biological treatment process followed. In general, the COD concentration decreased with reaction time. With ozone concentrations in the range from 150 mg/h to 300mg/h, when the ozone concentration increased, COD removal efficiency increased. Ozone concentrations in the range from 300 mg/h or higher changed the COD removal efficiency between the different levels ozone unsignificantly. According to the test results, the response time was the most effective from 45 minutes to 60 minutes.Therefore, we chose the reaction time from 45 minutes to 60 minutes. In addition, since the ozone concentration of 300 mg/h is the concentration of the most effective treatment compared with other concentrations; ozone concentrations 300 mg/h should be selected for the processing.

Control experiments showed that treatment efficiency of pollutants in waste water by using ozone combined the graphite electrodes of 12 V. Under the effect of electrochemical energy, oxidants have dissociated to form strong oxidative attack and compounds in wastewater pollution, dividing them into simpler compounds which were good for biodegradable treatment.

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